

No. 1. — *The Palolo Worm, Eunice viridis (Gray).*

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THE Palolo worm¹ first became known from the Samoan Islands, where it attracted the attention of the missionaries because it was eaten, prized and sought for by the natives, and because it appeared periodically in certain localities in enormous numbers, and for a few hours only, and because it made its appearance almost invariably in the months of October and November, and always during a quartering of the moon, and was not seen again until the following year under precisely the same conditions. It further became known that the November crop was vastly larger than that of October, and that *all* "Palolo" were *headless*.

The earliest published description of the "Palolo" is that by J. E. Gray (1847), based on material sent to the British Museum by the Rev. J. B. Stair, a missionary in the Samoan Islands. Gray placed it near to the Arenicolidae and gave it the name *Palola viridis*. It was figured by Macdonald (1858), and although his figures are most accurate, the so-called head is that of a Lysidice, as was pointed out by Ehlers (1868), who renamed it *Lysidice viridis*. The first extended account was written by Collin (1897) as an appendix to Krämer's earlier work on Samoa. Collin, with previous writers, considered the "Palolo" to be the posterior part of a Lysidice, a few heads of which had, from time to time, been taken with the "Palolo" at the 'fishing' season, and as no other annelid heads were taken, and all "Palolo" were headless, it was natural, for want of better evidence, to ascribe the "Palolo" to the genus Lysidice.² For thirty years it was ascribed to that genus, and Macdonald's

¹ In the Fijian Islands the worm is called "Bololo," pronounced Mbololo by the natives. In the course of the present paper I shall use the Samoan name Palolo, for it was in the Samoan Islands that it was first heard from and its true history became known. When the name is printed "Palolo," *i. e.* in quotation marks, I refer to the headless, epitokal, free-swimming portion of the worm. Different writers have spelled it Pulolo and Palola. It has also been called the "Fiji Worm."

² Quartrefages (1858) calls it *Lysidice palola*.

figures were the only ones,¹ and were often copied. In 1898 Friedlaender (1898^a) figured the head of what he recognized to be that of a Eunice. This, with other material, he obtained from the reef-rock at Samatau in Samoa. His material was afterwards studied by Ehlers, who (1898) showed that Friedlaender had found the real head of the "Palolo," which then became *Eunice viridis* (Gray).

It was my good fortune, while acting as assistant to Mr. Alexander Agassiz in the Fiji Islands, to be present at the annual 'rising' of the "Palolo" (Mbololo) at Levuka on November 17th 1897, and Mr. Agassiz has (1899, p. 16) given an account of our experiences at that time. In the following year Mr. Agassiz dispatched me to Samoa to be on hand for the November appearance of the "Palolo" and to search the reef-rock for the entire animal. On my arrival at Apia I was fortunate in finding Dr. Krämer, who placed his notes at my disposal as well as all of the annelid material he had collected from the reefs in his search for the Palolo head. I am also under obligations to Mr. W. Blacklock, U. S. Vice Consul at Apia, to Captain Victor Schoenfelder of H. I. M. S. "Falke," to my friend C. L. Crehore who accompanied me to Samoa, and to Tui Malealiifanu, the head chief of Falelatai where I made my headquarters.

After searching the reefs to the westward, at Samatau, where Friedlaender obtained his material, for several days without result, the natives took me to a small bay called Fagaiofu to the eastward of Falelatai. The bay lies between two small promontories which are about one quarter of a mile apart, and is almost filled with a fringing reef, the sea edge of which is not more than two hundred feet from the beach at extreme low tide. Small patches of dead coral occur almost at the beach line, becoming larger and more numerous seawards, where they are more or less confluent so as to make a kind of platform. This general platform is interrupted by two deep narrow channels or passages corresponding to the outlets of small streams. At extreme low tide, that is at neap tide, the place is so shallow that one can wade from the shore to the outer edge of the reef platform. The reef at Fagaiofu is composed of dead coral and the usual honeycombed reef-rock, except at the outer edge where there is living coral. By prizing off masses of the rock with a crowbar at the edges of the deeper channels, "Palolo" were disclosed in great numbers and could be seen dangling from the freshly exposed surfaces, and wriggling free into the water to be

¹ McIntosh (1885) figured some chætæ from material obtained by the "Challenger."

carried seaward by the retreating tide. This was about one hour before dead low water, and just before sunset on November third, two days before the "Palolo" was expected. Masses of the rock were taken back to Falelatai and by means of chisels, forceps, and lamplight, one specimen was obtained complete. The next day, the eve of the expected 'rising', we again went to Fagaiofu to camp for the night, and at low water obtained more material, including three complete specimens. Owing to the great length of the worm and its intricate association with the reef-rock the operation demands patience and delicate handling. It is in the galleries and cavities of the reef-rock that the Palolo has its abode. They were found everywhere on the reef and could be exposed by breaking open the surface, but more easily at the edges of the deeper places. Plate 3 shows, in natural size, a piece of the reef-rock presenting a top view and an end view showing the fractured surface. Fagaiofu is not easy of access, and a boat can land only when there is enough water over the reef. The platform can be worked only at extreme low tides which, in the Palolo season, are the neap tides, and occur about sundown and sunrise. This season is also the rainy season. Stair was present at the "Palolo" 'rising' at Fagaiofu in 1847 and (1897), speaks of it as "one of the famous fishing places." It is strange that I should have been the first to visit the place since his time, and almost by accident, and by only a narrow margin of time. The place is an ideal one for the study of the Palolo, if one could be there during some weeks covering the time of its swarming.

I must speak, as briefly as possible, of the petty discussion which appeared between 1898 and 1903 as to whom belongs the credit of first discovering the real head of the "Palolo." In March, 1898, Friedlaender (1898) states that the meaning of the Palolo phenomenon was simultaneously discovered by Krämer, Thilenius, and himself.¹ In May of the same year, Friedlaender (1898^a) says that the nature of the Palolo was discovered simultaneously by Thilenius and himself, and later (1904), it reads that he alone, and possibly Thilenius, made the discovery. In this paper he quotes me as saying (1903) that it was through Krämer's investigations that the true history of the Palolo became known. I refer Dr. Friedlaender to the English edition of my preliminary paper (1903^a) which was translated for Krämer's "Die Samoa Inseln," though not published until a few months later, to see that I was not unfair to him, as he charges. The discovery of the origin of the

¹ In his subsequent publications he makes no mention of this paper, but speaks (1904) of his second paper (1898^a) as "meine erste Abhandlung."

"Palolo" was made independently by Krämer and Friedlaender, although the latter was the first to publish an account of his investigations. Friedlaender succeeded in obtaining from the reef-rock at Samatau several specimens of "Palolo," together with the head ends of an annelid of different appearance and much larger size belonging to the genus *Eunice*. Friedlaender was the pioneer, for he was the first to identify the large head-end as that of a

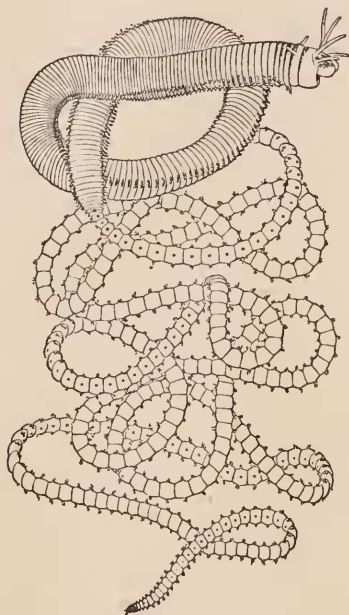


FIGURE 1.

Eunice viridis (Gray). The narrower posterior, epitokal part, when detached and free-swimming, is known as the "Palolo." About natural size.

the large head-end as that of a *Eunice*, and was the first to figure it as well as the transition piece between it and the "Palolo," and it was from his material that Ehlers gave us the final name *Eunice viridis* (Gray). All that I can hope to do is to establish, beyond doubt, the origin of the "Palolo," and confirm the researches of Friedlaender and Krämer, and add something to our knowledge of the morphology, habits, and relationships of this once mysterious worm.

It was Ehlers (1898) who first gave a detailed description of the Palolo worm and recognized an extreme case of sexual dimorphism, and showed the "Palolo" to be the epitokal posterior portion of *Eunice viridis* (Gray). He says (1898), "Ich ergänze das im Voraus damit, dass ich die *Eunice*, die nun den Namen *Eunice viridis* (Gray) erhält, in den Kreis der *Eunice siciliensis* Gr. bringe und an ihr die "Ausbildung

des "Palolo" als eine Form der Epitokie auffasse, wie sie zum ersten Male aus der Familie der Euniceiden, und in ihrer Besonderheit abweichend von allen Erscheinungen der Epitokie, die von Borstenwürmern bekannt sind, sich darstellt. Demnach ist in der Art eine atoke und epitoke Form, in der letzteren eine atoke und epitoke Körperstrecke zu unterscheiden." We have then in the Palolo, combined in the same individual, an atokal and an epitokal part corresponding to the anterior and posterior ends of the animal (Text Fig. 1), and it is the posterior epitokal

part, the "Palolo," that is periodically cast off and leads such an ephemeral existence, while the anterior atokal part remains in the galleries of the reef-rock to regenerate, by a process of strobilization, a new posterior atokal sperm or egg sac, which at the appointed time is again set free. The sexes are different in color, the color of the male being reddish brown or buff to yellowish, while that of the female is a deep bluish green (Figs. 1 and 2). These colors are very pronounced in the epitokal region, and are due to the sexual elements, ova and sperm. After the discharge of the sexual elements the collapsed integument is colorless and translucent. These distinctive sexual colors are found in the broader anterior atokal region, but not in so marked a degree, the female being only a little more greenish in color than the male, and here the colors are doubtless integumentary (Fig. 3). It is from the deep green color of the ova in the epitokal region that the specific name *viridis* is derived. Ehlers (1898) has so minutely and accurately described the worm that it would be superfluous for me to quote at length the details written by the master's hand, and I refer the reader to his paper. I can only supplement his description by additional measurements, etc., from more abundant material, and supply some figures.

The length of the "Palolo," that is the free-swimming epitokal part of the worm, has been variously estimated at from a few inches to three feet, *i. e.*, a maximum of 90 cm. This great length is given by Gill (1854). The longest specimen that I measured in the living condition was 30 cm. This is about the average of the measurements given by seven authors. From alcoholic material, where there is considerable shrinkage, Ehlers estimated 20 cm, and states that some segments were probably missing. The atokal region comprises about one fourth of the total length of the worm, and the greatest diameter is about 4 mm, while the length of the segments is about $\frac{1}{2}$ mm, or about twenty times as broad as they are long. This ratio begins at about the fifteenth segment from the anterior end, not counting the two large cephalic segments (Fig. 3). The ratio of length to breadth of these fifteen segments is about five to one. In the first of the two large cephalic segments the ratio is about two to one, and in the second four to one (Figs. 3 and 7). The broader anterior segments are also marked by a brown pigment which is densest on the dorsal surface, diminishing toward the sides and disappearing toward the ventral surface. It is densest in the two large cephalic segments diminishing posteriorly, and ceases at about the fifteenth segment, where they become shortest (Fig. 3). In one male specimen 429 atokal segments were counted, in another 350. These

counts are not accurate owing to a dense gelatinous secretion in the posterior part, which makes it difficult to count the very short segments. The region of this secretion, in the longest of the atokal specimens, began at about segment 300 and extended backward to the narrow epitokal region. The transition between the broad atokal and attenuated epitokal regions is abrupt and very marked (Text Fig. 1 and Fig. 10, Plate 2), owing to the difference in diameter and shape of the segments and the difference in color due to the sexual elements in the epitokal segments. The diameter of the epitokal segments is, in general, slightly more than 1.50 mm in alcoholic material, and the length is about the same. In the living animal the length of the segments is slightly more than the breadth. The epitokal region has somewhat the appearance of a string of beads, the segments being rounded, bulging at the middle and constricted at the dissepimental zones (Text Fig. 1). As has already been mentioned, the epitokal region is but an egg or sperm sac and leads but a brief free existence, and as will be seen later, the rounded, plump shape of the segments can be explained by the suppression of organs due to the crowding effect of the sexual products. Beginning at about the fifteenth from the posterior end, the segments become narrower and more flattened so that the posterior end tapers to the last or anal segment. Varying from two to fifteen in number, the preanal segments are colorless and translucent, not containing any sexual elements (Fig. 9). The cephalic and anal cirri (Figs. 3 and 9), the chætae (Figs. 13 and 14) and the jaw apparatus (Figs. 11 and 12), are characteristic of the genus, and have been minutely described by Ehlers. The great length of the cirri on the first pair of parapodia described by him is plainly seen in Figure 3. Ehlers finds many resemblances between *Eunice viridis* and *E. siciliensis* Gr. in which species there is also, at sexual maturity, an intensification of the color in the posterior region. With Ehlers, I found the gill filaments in the atokal region to begin at about the 135th segment. They attain their greatest length at about segment 175. The presence of gill filaments in the epitokal part is difficult to determine. When they are present they are much aborted, and there is no particular region where they can always be found. They are constantly absent in the empty, translucent, preanal segments. Ehlers believes that where the gill filaments are lacking in the epitokal region they have been lost, "abgefallen," due to their slight union with the dorsal cirrus, and that the loss of them may be due to one of the regular processes involved in the life of the "Palolo." This is in accord with other processes that take place, such as the general histol-

ysis of internal organs to make room, as it were, for the accumulation of sexual products, and the reduction in the number of chætae in the parapodia, processes adapted to its function and brief existence; while the life of the atokal, parent-end is, as far as known, perennial. The general shape of the parapodia in the atokal and epitokal regions is the same; those of the anterior region being perhaps somewhat broader, and containing a larger bundle of chætae, both simple and compound. In the epitokal region I found usually, even as far back as the thirteenth preanal segment, two of the simple, dorsal chætae and three of the ventral compound ones (Fig. 13), while Ehlers says, "ist häufig nur eine einfache und eine zusammengesetzte Borste vorhanden." A reduction of organs and histolysis of tissues in epitokal forms of annelids has been noted by Ehlers (1868) in *Glycera*, Caullery and Mesnil (1898) in *Dodecaria*, by Claparède (1870) in *Polyopthalmus* and *Pædophylax*, Eisig (1887) in *Notomastus*, etc., and McIntosh (1885) has spoken of it in the "Palolo." The intestine is reduced to a thin flattened ribbon, and the segmental organs are difficult to determine, more especially so in the female. Also there is a great reduction in the thickness of the body wall, a condition that exists in other annelids at sexual maturity.

All sexual products, according to Powell (1883), are discharged through "oviducts and seminal ducts," and Ehlers believes, with Powell, that the sexual products are discharged by means of "ausführende Apparate." My observations do not agree with this. In Fiji I isolated single individuals in separate vessels and observed the discharge of the sexual products, which was best seen in females on account of the large size and deep color of the ova. In one instance, a female of about ten inches in length, the ova were discharged as if simultaneously from all segments, leaving a small mass of shriveled translucent pellicle. It seemed incredible that so large a worm could be suddenly reduced to so small a mass. The process was like an explosion, and the ova must have been under great tension. When a few specimens were kept in the same vessel, the number of heaps of green granules at the bottom of the vessel indicated the number of females that had discharged their ova. On examination of the collapsed integument, distinct lateral rents or tears could be seen, and could, in some cases, be traced confluent through several segments. The large size of the ova, 14.5μ in diameter, would preclude any rapid discharge by means of segmental organs. On the other hand I believe that some of the male elements may find their way out through the segmental organs as they can be demonstrated there in sections, yet living males "explode" in the same

way as females. Eisig (1887) describes similar conditions in *Notomastus*, where the sexual elements are discharged by rupture of the body-wall, and states that the lumen of the segmental organs is too small for the passage of ova. Mayer (1900), for his "Atlantic Palolo," says that by series of violent and sudden contractions "the ripe segments are torn asunder at short intervals by the breaking of the cuticula, forming large rents through which the genital products escape." This manner of unloading the sexual products accounts for the apparent sudden disappearance of the dense swarms of "Palolo" a short time after their appearance, which was considered as much of a phenomenon as their sudden appearance.

Each segment of the atokal part bears on its ventral surface a prominent circular pigmented spot, deep brown or black in color (Text Fig. 1, Figs. 9 and 10, plate 2). They can be traced forward into the atokal region through about twenty segments, though much reduced in size, and paler in color (Fig. 10). They are absent in from two to fifteen of the preanal segments, those colorless, translucent segments that contain no sexual elements. They were first noted by Ehlers (1868) who likened them to eyes in appearance, but looked upon them as the external openings of some sort of a longitudinal gland. It was Spengel (1881) who first estimated their true nature, and speaks of them as "wirkliche Augen." The minute structure of these ventral eye-spots was studied by Hesse (1899) in carefully prepared material collected by Krämer. Although he states that it is improbable that they are capable of forming images, he says: "Es wird also ihre Leistungsfähigkeit auf die Unterscheidung verschiedener Lichtintensitäten, vielleicht auch von Farben, und auf das Erkennen der Lichtrichtung beschränkt sein." Schroeder (1905), who also made an histological study of these eye-spots, asserts that they differ so much in structure from all known eyes that it is not possible to compare them with any. He hints at the possibility of their being light-producing organs. If they were phosphorescent organs it would have been noted long ago, and could not have escaped the eyes of the natives, as the "Palolo" appears in dense swarms at the surface of the water, and in deep darkness. It is significant that these eye-spots occur in a rudimentary form on only a few of the posterior segments of the atokal, sedentary, part of the worm, and are so highly developed on all but a few of the segments of the active, epitokal part. I believe with Hesse that they react in some way to light, or possibly to heat rays. In text Figure 2, I reproduce Hesse's figure of a median section of one of these eyes, which plainly shows their structure.

On the day before the 'rising' of the "Palolo" (the *motusaga* day of the natives, see *infra*), a small annelid, headless like it, and the sexes also distinguished by brown and greenish tints, makes its appearance in large numbers. It is this small worm that in my preliminary paper (1903) I ascribed to *Lysidice falax*, the name that Ehlers gave to the Lysidice-head figured by Macdonald, and for so long believed to be the



FIGURE 2.

Longitudinal medium section of one of the ventral eye-spots of the "Palolo." After Hesse. $\times 400$. v. n. c., ventral nerve-cord; p. m., pigment mass; ep., epithelium.

real head of the "Palolo." This small headless worm, a diminutive "Palolo," does not belong to *L. falax*. I have complete specimens of the latter which in no way exhibit any heteramorphosis or differentiation between the anterior and posterior regions. A description of *L. falax* is reserved for a subsequent paper on Eunicidae from the reefs of the Pacific Islands. To the little "Palolo" of *motusaga* day I give the tentative name *Eunice dubia*. The segments have the same general shape as those of the "Palolo" and measure, in alcoholic material, about 0.75 mm; in diameter, being slightly shorter than broad (Figs. 4 and 5). As

in *E. viridis* about twelve of the preanal segments are colorless and translucent, not containing any sexual elements. These empty segments are usually much wider than those preceding them, thus marking off a distinct broader preanal region (Fig. 5). The longest specimen measured 3 cm, from the material collected by Krämer at Apia. Usually there is present, in each segment, a pair of brownish or blackish pigmented spots at the dorsal base of the parapodia (Fig. 6). These are not comparable to the ventral eye-spots of *E. viridis*, but rather to the paired pigmented "glands" so common in the Alciopina and Tomopteridae and, possibly, have a photogenic function. Treadwell (1900) has described similar paired organs in *E. armata*. The composition of the parapodia (Fig. 15) is much simpler than in *E. viridis*. There are two of the simple chætae, one much longer than the other, and but one of the compound kind. The figure does not show the cirri which are much shorter than in *E. viridis*, and gill filaments could not be determined; the figure is inverted.

The first detailed account of sexual dimorphism in annelids is by Alexander Agassiz (1862) for *Autolytus*, and Malaquin (1893), has called attention to its occurrence in other Syllidae. In the Nereidae, sexual dimorphism was first described by Ehlers (1868) where it is known for upwards of twenty species, and it is manifested in different ways pretty much throughout the Annelida. It occurs in two general ways. First, as in the Nereidae, where certain sexual individuals undergo a metamorphosis adapting them for the dissemination of the sexual products (Heteronereis), and secondly as in the Eunicidae ("Palolo"), where certain regions of the animal, containing the sexual elements, become modified and are set free by a process of autotomy. In the first case the metamorphosed individuals are known as the epitokal (Ehlers, 1868) or epigamous (Claparède, 1870) forms, in the latter the sexually modified part which is set free is the epitokal part of the animal, the unmodified part, the parent animal, which may or may not regenerate the liberated portion, is the atokal part. In the latter class it is usually the posterior portion that is set free as in *Eunice viridis*, *E. fucata* (Mayer, 1900, 1902) Syllidae, etc., while in *Ceratocephale osawai* (Izuka, 1903), one of the Nereidae, it is the anterior region that leads a free existence. In most epitokal forms there is a great development of the eyes. In the Nereidae, the active epitokal form is attracted by artificial light, and Izuka (1903), states for *Ceratocephale* that the fishermen attract them by the light of torches, catching them for bait. I have observed the same attraction to artificial light in several forms of Heteronereis. This development of the eyes in epitokal phases of annelids is significant, and as I have pointed

out the ventral eye-spots are fully developed only in the posterior free-swimming part of the Palolo.

According to Rikkenbach (1902) autotomy (Selbstverstümmelung) in annelids is brought about through external stimuli, and the parent atokal part of the Palolo may be looked upon as a sexual nurse or stock which regenerates the epitokal region, a process comparable to strobilization in cestodes. Brunelli and Schoener (1905), who name this process schizoeptokie, call attention to the fact that the most complicated reproductive processes in annelids exist in those forms that inhabit shores and reefs, are simpler in pelagic forms, still less complicated in fresh water forms, and simplest of all in terrestrial forms. In the phenomenon of the periodic appearance of the "Palolo" they believe that inorganic forces have played the most important part in establishing reproductive autotomy, and since annelids inhabiting reefs and shores are subject to wounds and amputations due to the action of the waves on rock-fragments and sand, and friction between the worm and the rock, etc., epitokie arose from such amputations, which later became simple division and finally adapted to the dissemination of the species, and since these mechanical causes were coincident with certain seasons, such a periodic seasonal mechanical stimulus has played an important role in the ancestral history of the Palolo.

The periodic swarming of the "Palolo" has been ascribed to various stimuli such as light, heat, salinity and pressure of the water, atmospheric electricity, etc. Friedlaender (1898), says that a reaction to light has nothing to do with the "Palolo" phenomenon, neither moonlight, which is reflected light, nor the light of dawn, and suggests a negative geotropism through diminished water pressure at low tides. The "Palolo" appears in the months of October and November in the last quartering of the moon. This is the season of neap tides, when the reef flats are uncovered or only awash. At this season the sun is nearest the zenith in southern latitudes, a season when the sun's light and heat is greatest. I believe in some heliotropic or thermotropic reaction of the eye-spots borne on the segments of the epitokal part of the Palolo. A glance at Text Fig. 2, p. 11, showing the structure of one of these ventral eye-spots is more than suggestive that their function is to react in some way to light or heat rays. Friedlaender's contention that the "Palolo" appears in almost absolute darkness does not, to my mind, preclude a reaction of the eye-spots to light or heat, for these influences have been acting for a considerable period of time as there are three distinct days involved in the 'rising' of the "Palolo."

The "Palolo" makes its appearance twice a year and always in a quartering of the moon, at a neap tide in October and November. For Fiji the October rising is known as "Bololo lailai," *i. e.*, small or few "Palolo;" the November one is called "Bololo levu," *i. e.*, large or many "Palolo." The October crop is not large enough to interest the natives in its capture, but marks in a way the time for the appearance of the great November crop.¹ There are various signs known to the natives by which they reckon when to expect the swarming of the worm, such as the distance above the horizon of certain constellations, the "march" to the sea of the land crabs to deposit their eggs, the appearance of certain small fish, the ripening of certain tubers, the flowering of plants, etc. An old Fijian chief told me that you might expect the "Bololo" when in the last quartering of the moon in October and November there is a low tide just before sunrise. This spring season is recognized throughout the Pacific islands, and where the "Palolo" occurs the native calendar bears its mark as to the names of seasons and months. All of the annelids living in the reefs are sexually mature at this time, as shown by the extensive collections made by Krämer and myself, and this is true of the general animal life of the reef. In Samoa this season is known as *taumafamua*, *i. e.*, the time of much to eat. In the Banks Islands, Mota (Codrington, 1891), the season is called *tau matua*, the season of maturity.²

Good accounts of the fishing of the "Palolo" are given by Churchill (1902), Churchward (1887), Krämer (1902), the Earl of Pembroke (1872), Seeman (1862), Stair (1897), Thompson (1896), von Werner (1890), and others. The 'Palolo-time' embraces three successive days. When in the last quarter of the moon in October and November, more especially the latter, the water on the 'Palolo-grounds' has a turbid or roiled look, with floating patches of scum, the natives know that two days later the "Palolo" will 'rise.' This first day is called *salefu*. The second day is marked by the swarming of a small annelid, headless like the "Palolo," and the sexes distinguished by the same yellow and greenish tints. This day is called *motusaja*. The third is the *tatelega* when the "Palolo" swarms and the natives come many miles to the favoured places to gather it. With "Palolo" of the *tatelega* day many of the small annelids of the *motusaja* occur, and a few "Palolo" appear

¹ I can offer no explanation why there should be two distinct crops and in adjacent months, nor why the November crops should be so much larger.

² It is not in the province of this paper to enter into the legends, folk-lore, and ceremonies of the natives with which the "Palolo" has so much to do.

on *motusaga* day. A microscopical examination of the *salefu* scum shows it to consist of a gelatinous slime in which are grains of sand, appendages, fragments and casts of Eutomostraca, and a varied detritus of the seething life inhabiting the reefs, including many ova of various kinds in different stages of segmentation. The *salefu* may be looked upon as a manifestation of the awakening of the "Palolo" previous to its swarming or marriage-swim; an annual activity of countless numbers of annelids resulting in a discharge into the water of the deposits accumulated in the galleries and crevices of the reef-flats. The small annelid of *motusaga* day is what I have called *Eunice dubia* (Figs. 4-6, 15) and is doubtless what Friedlaender speaks of as the "Pseudopalolo." The "Palolo" appears in some localities in such enormous numbers that the surface of the sea has been likened to a thick vermicelli or macaroni soup, and I have seen a native with his bare hands fill a large pail with the worms in a few minutes. In Fiji I have seen the natives testing the water by wetting their hands and smelling it, and in this way detect the presence of the worm before it had been seen. I was unable to learn of this method in Samoa. The "Palolo" is eaten raw, but more usually baked in leaves of the breadfruit or boiled. The mass resembles cooked spinach in appearance, the whole taking on the deep green color of the female. In taste and smell it is not unlike fresh fish roe. It is eaten with impunity by both old and young, and in Fiji the water in which it is boiled is sometimes given to the sick.

The "Palolo" is known from Samoa, Fiji, and Tonga. It occurs on all of the larger of the Samoan Islands and throughout the Fiji group. Early records of the time of its appearance in Fiji have been kept at Lakamba from 1845-1854, and at Levuka from 1854-1858. In every case its appearance was in a quartering of the moon, which is true also of Whitmee's records for Savaii in Samoa (1862-1868) and the later records from both groups of islands.

The earliest recorded observations of the swarming of annelids are those of Rumphius (1705) for the "Wawo" of Amboina for the years 1684 to 1694. The recent "Siboga" expedition brought back specimens of this worm which were studied by Horst (1905) who named it *Lysidice oele* (see also Weber, 1902). As in the "Palolo" its annual appearance is directly related to a phase of the moon, as it makes its appearance in March and April only on the second and third nights after full moon. This relation of swarming of annelids to phases of the moon is noted by Mayer (1900 and 1902) for *Eunice fucata*, and Izuka

(1903) for *Ceratocephale osawai*. A similar swarming of marine annelids, and at corresponding seasons, is known for other islands of the Pacific, though the worms have not everywhere been identified. Powell (1883) speaks of them in the Gilbert Islands where they are known to the natives as *te nmatamata*, and Codrington (1891) gives a detailed account for Mota in the Banks Islands where they are known as *un*. Brown (1877) mentions an annual appearance of a "Palolo" on the East coast of New Ireland. That the annelid is best known from Samoa and Fiji is accounted for by these two groups of islands having been most visited and longest inhabited by whites. It is significant also that such records as we possess from other places, though meagre, have come to us through the missionaries, the pioneers of intelligent whites in the islands of the Pacific.

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